

## THE *YUGA* OF THE *YAVANAJĀTAKA*

### DAVID PINGREE'S TEXT AND TRANSLATION REVIEWED

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(Received 4 October 1988)

#### INTRODUCTION

The *Yavanajātaka* written by Sphujidhvaja Yavaneśvara in the third century A.D. was edited and translated into English by Prof. David Pingree in 1978. The last chapter (ch. 79) of this work is called *Horāvidhi* and deals with luni-solar astronomy on the basis of a period of 165 years called *yuga* and the synodic motion of the planets. The text is marred by faulty editing, the incorrect readings being adopted and the correct ones given in the apparatus criticus, with the result that the translation is incorrect at places and the meaning really intended by the author is lost.

The object of the present paper is to study this chapter so as to bring out the meaning really intended by the author. The paper will be confined to the study of the *yuga* of the *Yavanajātaka* and its various constituents. In the process the relevant passages and their translation as given by Prof. Pingree will be reviewed and modified.

#### I. TIME-MEASURES

Verses 28-29 of Chap. 79 of the *Yavanajātaka* give a table of time-measures. Pingree's text and translation run thus :

Text : त्रयः पलाः स्युः कृड्वोष्टमश्च  
तत्राडिकाख्यं विदुरेकषष्टिम् ।  
ताः षष्टिलिप्तापि च नाडिकाख्या  
भवन्ति षष्टिद्युनिशा क्रमेण ॥२८॥

कला निमेषाष्टशता दशोना  
 विदुः कलास्त्रिंश [च] नाडिका तु ।  
 द्विनाडिकस्तु प्रथितो मुहूर्तो  
 मानप्रमाणादिविधिप्रसिद्धौ ॥२९॥

*Trayaḥ palāḥ syuḥ kuḍavo 'ṣṭamaśca  
 tannāḍikākhyam vidurekaṣaṣṭim {*  
*Tāḥ ṣaṣṭilīptāpi ca nāḍikākhyā  
 bhavanti ṣaṣṭirdyuniśā krameṇa || 28 ||*  
*Kalā nimeṣāṣṭaśatā daśonā  
 viduḥ kalāstrimśa [ca] nāḍikā tu {*  
*Dvināḍikastu prathito muhūrto  
 mānapramāṇādividhiprasiddhau || 29 || )*

*Translation :* A kuḍava is  $3\frac{3}{8}$  palas, and 61 kuḍavas equal 1 nāḍikā. The nāḍikās are also each divided into 60 līptās ("minutes"); there are 60 nāḍikās in a nychthemeron. One kalā equals 790 (?) nimeṣas, one nāḍikā 30 kalās, and one muhūrta 2 nāḍikās in the accomplishment of the rules relating to measures and standards.

*Remarks :*

(1) We find that according to this translation one nāḍikā is equal to 30 kalās, whereas in the formulation of the rules stated in vss. 11, 12 and 13 one muhūrta ("a period of 2 nāḍikās") is taken equal to 20 kalās, and in verse 31 also one kalā has been used in the sense of 1/10 of a nāḍikā or 1/20 of a muhūrta. This discrepancy is due to the adoption of the incorrect reading "kalāstrimśa [ca]" (in vs. 29b) in place of the correct reading "kalāstā daśa" which has been given in the apparatus criticus. Restoring the correct reading in place of the incorrect one, we find that the text gives the following table :

$3\frac{3}{8}$ palas	=	1 kuḍava
61 kuḍavas	=	1 nāḍikā
60 līptās	=	1 nāḍikā
60 nāḍikās	=	1 nychthemeron
790 nimeṣas	=	1 kalā
10 kalās	=	1 nāḍikā
2 nāḍikās	=	1 muhūrta (or kṣaṇa).

Likewise

$$\begin{aligned} 20 \text{ kalās} &= 1 \text{ muhūrta} \\ 30 \text{ muhūrtas} &= 1 \text{ nychthemeron.} \end{aligned}$$

It is these two relations that have been used in verses 11, 12 and 13. The same relations were given by Suśruta<sup>1</sup> and Parāśara.<sup>2</sup>

(2) It is noteworthy that according to the *Vedāṅga Jyautiṣa*<sup>3</sup> too,

$$\begin{aligned} 3\frac{1}{8} \text{ palas} &= 1 \text{ kuḍava} \\ \text{and } 61 \text{ kuḍavas} &= 1 \text{ nāḍikā.} \end{aligned}$$

But there

$$1 \text{ nāḍikā} = 10\frac{1}{20} \text{ kalās.}$$

It seems that Sphujidhvaja Yavaneśvara has taken

$$1 \text{ nāḍikā} = 10 \text{ kalās}$$

to avoid fractions, or he has followed Suśruta or Parāśara.

## 2. TITHIS IN THE YUGA

Verse 6 gives the number of *tithis* in the *yuga* ("a period of 165 years"). Pingree's text and translation run thus :

Text : क्रमेण चन्द्रः क्षयवृद्धिलक्ष्य-  
स्तिथिश्चतुर्मानविधानबीजः ।  
षट्पञ्चकाग्रे द्विशते सहस्रं  
तेषां युगे बिन्दुयुतानि षट् च ॥६॥

*Krameṇa candraḥ kṣayavṛddhilakṣya-*  
*stithiścaturmānavidhānabijāḥ |*  
*Ṣaṭpañcakāgre dviśate sahasraṃ*  
*teṣāṃ yuga binduyutāni ṣaṭ ca || 6 ||*

**Translation :** The Moon is to be characterized by waning and waxing in order. The *tithi* possesses the seed of the principles of the four (systems of time-) measurement. There are 60,265 (days) in a *yuga*.

<sup>1</sup> See *Suśruta Saṃhitā*; *Sutrasthāna*, ch. vi. 4.

<sup>2</sup> See *Bṛhat Saṃhitā* with Bhattotpalā's Commentary, Sudhakara Dvivedi's edition, p.24, lines 3-5.

<sup>3</sup> See *Yajusa Jyautiṣa*, vs. 24.

*Remarks :*

The last sentence of this translation is wrong. The number 60,265 as well as its designation as "days" both are incorrect. The word *ṣaṭpañcaka* means  $6 \times 5$  i.e. 30, not 65 ; and the word "*teṣāṃ*" refers to *tithis*, not to civil days. Moreover, the number of civil days in a *yuga* is 60,272, not 60,265. See below.

The second half of the text really gives the number of *tithis* in the *yuga*, not the number of civil days in the *yuga* as supposed by Pingree. The error is due to faulty editing of the text. The adoption of the incorrect readings "*°kāgre dviśate*" and "*bindu*" in place of the correct readings "*°kāgrā dviśatī*" and "*viddhya*", respectively has spoiled the text. It is noteworthy that the correct readings are given in the apparatus.

The correct reading of the text is :

क्रमेण चन्द्रसयवृद्धिलक्ष्य-  
स्तिथिश्चतुर्मानविधानबीजः ।  
षट्पंचकाग्रा द्विंशती सहस्रं  
तेषां युगे विध्ययुतानि षट् च ॥६॥

*Krameṇa candrakṣayavṛddhilakṣya-*  
*stithiścaturmānavidhānabījaḥ* |  
*Ṣaṭpañcakāgrā dviśatī sahasraṃ*  
*teṣāṃ yuge viddhayutāni ṣaṭ ca* || 6 ||

meaning : "The tithi, which is the indicator of the gradual waning or waxing of the Moon, is the seed of the principles of the four (systems of time-) measurement. Know that there are 60000 plus 1000 plus 200 and  $6 \times 5$  (i.e. 61,230) of them (in a *yuga*)."

That is,

one *yuga* = 61230 *tithis* (or 2041 synodic months, as stated in vss. 9 and 20c-d)

### 3. CIVIL DAYS IN THE YUGA

Verse 7 gives the number of civil days in the *yuga*. Pingree's text and translation run thus :

Text : त्रिंशन्मुहूर्तं दिनरात्रमुक्तं  
सूर्योदयात् कालबुधास्तदाहः ।  
तेषां शते द्वे त्रिंशदेककाग्रे  
षट् खायुतान्यर्कयुगं वक्षन्ति ॥७॥

*Trīṣaṇmuhūrtaṃ dinarātramuktaṃ*  
*sūryodayāt kālābudhāstadāhuḥ* ।  
*Teṣāṃ śate dve trīśadekakāgre*  
*ṣaṭ khāyutānyarkayugaṃ vadanti* ॥ 7 ॥

*Translation* : A nychthemeron is said to consist of 30 *muhūrtas* ; experts on time say that it begins with sunrise. They say that a *yuga* of the Sun consists of 61,230 (*tithis*).

*Remarks* :

The second sentence of this translation, though mathematically correct, is not the correct translation of the second half of the text. The number 61330 and its designation as "*tithis*" both are wrong. The word "*trīśat*" means 300, not 30 ; and it is difficult to interpret "*ekakāgre ṣaṭ khāyutani*" as meaning 61000. Also, the word "*teṣāṃ*" refers to nychthemera or civil days, not to *tithis*.

The second half of the verse really gives the number of civil days in a *yuga*, not the number of *tithis* in a *yuga* as supposed by Pingree. The error is due to the faulty editing of the text. The adoption of the incorrect readings "*trīśadekakāgre*" and "*ṣaṭ khā*" in place of the correct readings "*trīkṛdaṣṭakāgre*" and "*ṣaṭkhā*" respectively has marred the text. It is noteworthy that the correct readings are given in the apparatus.

The correct reading of the text is :

त्रिंशन्मुहूर्तं दिनरात्रमुक्तं  
 सूर्योदयात् कालबुधास्तदाहुः ।  
 तेषां शते द्वे त्रिकृदष्टकाग्रे  
 षट्कायुतान्यर्कयुगं वदन्ति ॥७॥

*Trīṣaṇmuhūrtaṃ dinarātramuktaṃ*  
*sūryodayāt kālābudhāstadāhuḥ*  
*Teṣāṃ śate dve trikṛdaṣṭakāgre*  
*ṣaṭkāyutānyarkayugaṃ vadanti* ॥ 7 ॥

meaning : "A nychthemeron (civil day) is said to consist of 30 *muhūrtas* ; experts on time say that it begins with sunrise. They say that a *yuga* of the Sun consists of 60000 plus 200 plus  $3^2 \times 8$  (i.e. 60,272) of them (i.e. civil days)."

That is,

one *yuga* = 60272 civil days.

The word "*trikṛt*" means  $3^2$  i.e. 9, and the word "*trikṛdaṣṭaka*"  $3^2 \times 8$  i.e. 72.

Further remarks on vss. 6 and 7 :

Pingree is aware of the fact that the second half of vs. 6 should contain the number of *tithis* in a *yuga* and the second half of vs. 7 the number of civil days in a *yuga*, but his text has landed him in trouble and he remarks : "A more logical order might be achieved by interchanging 6c-d with 7c-d." He also complains about Sphujidhvaja Yavaneśvara's way of expressing numbers in verse : "The extreme clumsiness with which Sphujidhvaja expresses numbers is a reflection of the fact that a satisfactory and consistent method of versifying them had not yet been devised in the late third century." But these remarks are uncalled for, as it is all due to the faulty edited text.

#### 4. CIVIL DAYS IN A SOLAR YEAR

Verse 34 gives the number of civil days in a solar year. Pingree's text and translation run thus :

Text : सपंचषष्टिं त्रिंशत् दिनानां  
 द्युनं द्विभिन्नं तु दिनांशकानाम् ।  
 त्र्युनं शतार्धं दिनकृत्समा स्याद्  
 यया भवति सविता भुनक्ति ॥३४॥

*Sapañcaṣaṣṭim triśatam dinānām*  
*dyūnam dvibhinnaṁ tu dināṁśakānām* |  
*Tryūnam śatārdham dinakṛtsamā syād*  
*yayā bhavargam savitā bhunakti* || 34 ||

Translation : A year of the Sun consists of 365 days and 14 ; 47 sixtieths (*amśas*) of a day, in which the Sun traverses the signs.

Remarks :

This translation is incorrect, because "14;47 sixtieths" does not yield the value of the solar year according to Sphujidhvaja. For, according to this translation

one solar year = 6,5;14,47 days,

whereas according to Sphujidhvaja

one solar year = 6,5;17,5,27,16 days.

The error is due to the adoption of the incorrect reading "*dyūnam dvibhinnaṁ*" in place of the correct reading "*yugādvibhinnaṁ*" given in the apparatus.

The correct reading of the text is :

सपंचषष्टिं त्रिंशत् दिनानां  
 युगाद्विभिन्नं तु दिनांशकानाम् ।

त्र्यूनं शतार्धं दिनकृत्समा स्याद्  
यया भवति सविता भुनक्ति ॥३४॥

*Sapañcaṣaṣṭiṃ triśatam dinānām  
yugādvibhinnaṃ tu dināṃśakānām |  
Tryūnaṃ śatārdham dinakṛtsamā syād  
yayā bhavargam savitā bhunakti || 34 ||*

meaning : "A *yuga* of the Sun consists of 365 days and a fraction of a day equal to fifty minus three divided by (the number of years in) a *yuga*, in which the Sun traverses the signs."

That is,

$$\begin{aligned}\text{one solar year} &= 365 + \frac{50-3}{165} \text{ civil days} \\ &= \frac{60272}{165} \text{ civil days,}\end{aligned}$$

This result confirms the statement of vs. 7 that there are 60,272 days in a *yuga* (consisting of 165 years).

#### 5. CIVIL DAYS IN A SOLAR MONTH

Verse 11 defines a civil month and gives the number of civil days *etc.* in a solar month. Pingree's text and translation run thus :

Text : त्रिंशद्दिनाः सावनमास आर्क-  
स्त्र्यग्रैर्विशिष्टा दशभिर्मुहूर्तैः ।  
कलाचतुष्केण च पंचषट्कै-  
स्त्र्यग्र्यांशकैश्च द्विगुणैश्चतुर्भिः ॥११॥

*Triṃśaddināḥ sāvanamāsa ārka-  
stryagrairviśiṣṭā daśabhirmuḥūrtaiḥ |  
Kalācatuṣkeṇa ca pañcaṣaṭkai-  
stryagryāṃśakaiśca dviguṇaiścaturbhiḥ || 11 ||*

Translation : A civil month equals 30 days, a solar month equals (a civil month) plus 13 *muhūrtas* and 4 *kalās* and 56 thirds and 2 fourths.

Remarks :

Here the text is correct<sup>1</sup> but the translation incorrect. For, "*pañcaṣaṭka*" means

<sup>1</sup> Read °*rviśiṣṭo* in place of °*rviśiṣṭā*.

5×6 i.e. 30, not 56 ; also "tryagryāmsaka" does not mean third, nor "catur" fourth. Moreover, according to this translation,

one solar month = 30;26,9,52,4 days

whereas, according to Sphujidhvaja,

one solar month = 30;26,25,27,16 days.

The correct translation is :

"A civil month equals 30 days, a solar month is greater (than that) by 10+3 *muhūrtas*, 4 *kalās* and  $\frac{2 \times 4}{5 \times 6 + 3}$  of a *kalā*."

Thus

$$\begin{aligned} \text{one solar month} &= 30 \text{ days} + 13 \text{ } \mu\text{h}\ddot{u}\text{rtas} + 4\frac{8}{33} \\ &= \frac{60272}{1980} \text{ civil days,} \end{aligned}$$

because 20 *kalās* = 1 *muhūrta* and 30 *muhūrtas* = 1 civil day.

This result also confirms the statement of vs. 7 that there are 60272 civil days in a *yuga*.

#### 6. CIVIL DAYS IN A SYNODIC MONTH

Verse 12 gives the number of civil days *etc.* in a synodic month. Pingree's text and translation run thus ::

Text : अह्नस्तु षट्पंचकमेकहीनं  
क्षणष्टकौ द्वौ द्विकलाविहीनौ ।  
कलालवाः सप्त शतं विदिष्टः  
समासभिन्नः शशिनः स मासः ॥१२॥

*Ahnastusatpañcakamekahīnam*  
*kṣaṇāṣṭakau dvau dvikalāvihīnau* {  
*Kalālavāḥ sapta śataṃ vidiṣṭaḥ*  
*samāsabhinnāḥ śaśinaḥ sa māsaḥ* || 12 ||

*Translation* : A (synodic) month of the Moon, which ends with a conjunction, consists of 29 days and 32 *kṣaṇas* minus 4 *kalās* and 107 sixtieths of a *kalā*.

*Remarks* :

This translation is based on misinterpretation of the text and does not accord to the teaching of Sphujidhvaja. For, according to this translation,

one synodic month = 30;3,55,34 days,



whereas according to Spkujidhvaja,

one synodic month = 29;31,50,14,24 days.

The error is really due to the adoption of the incorrect readings "*ahnastu*" "*śataṃ vidiṣṭaḥ*" and "*samāsabhinnāḥ*" in place of the correct readings "*ahnām tu*", "*śatī dviṣaṣṭā*" and "*svamāsabhinnā*" respectively which are given in the apparatus.

Thus the correct reading of the text is :

अह्नां तु षट्पञ्चकमेकहीनं  
क्षणाष्टकौ द्वौ द्विकलाविहीनौ ।  
कलासवाः सप्तसती द्विषष्टा  
स्वमासभिन्ना शशिनः स मासः ॥१२॥

*Ahnām tu ṣaṭpañcakamekahīnaṃ*  
*kṣaṇāṣṭakau dvau dvikalāvihīnau* |  
*Kalālavāḥ saptaśatī dviṣaṣṭā*  
*svamāsabhinnā śaśinaḥ sa māsaḥ* || 12 ||

meaning : "6×5—1 days, 2×8 *kṣaṇas* (*muhūrtas*) minus 2 *kalās*, and a fraction of a *kalā* equal to 762 divided by (the number of) its own (*i.e.* synodic) months (in a *yuga*) : this is (the length of) the (synodic) month of the Moon."

That is,

one synodic month = 29 days + (16 *muhūrtas* minus 2 *kalās*) +  $\frac{762}{2041}$  *kalā*,

because there are 2041 synodic months in a *yuga*, =  $\frac{60272}{2041}$  civil days,

because 20 *kalās* = 1 *muhūrta* and 30 *muhūrtas* = 1 civil day.

This again confirms that there are 60272 civil days in a *yuga*.

#### 7. CIVIL DAYS IN A SIDEREAL MONTH

Verse 13 gives the length of a sidereal month in terms of civil days, *etc.* Pingree's text and translation run thus :

Text : आर्क्षस्तु कृत्तिर्द्विगुणस्तु कृच्छ  
क्षणाः क्षणार्धं च कलासच तिस्रः ।  
कलाशकानां च त्रिसप्तकाग्रं  
क्षतं विभक्तौ दलितैः समासैः ॥१३॥

*Ārkṣastu Kṛttirdviguṇastu kṛcca*  
*kṣaṇāḥ kṣaṇārdham ca kalāśca tisraḥ* |  
*Kalāṃśakānāṃ ca trisaptakāgram*  
*śataṃ vibhakto dalitaiḥ samāśaiḥ* || 13 ||

*Translation* : A sidereal month consists of 27 days plus  $8\frac{1}{2}$  *kṣaṇas* and 3 *kalās* and 137 sixtieths of a *kalā* : it is separated by half-conjunctions (?).

*Remarks* :

The first line of the text is corrupt and the translation is arbitrary and wrong. "Trisaptaka" does not mean 37 ; it means  $3 \times 7$  or 21. It is difficult to understand how the first line has been interpreted in that way.

According to the above translation,

one sidereal month = 27;17,10,34 days

whereas according to Sphujidhvaja,

one sidereal month = 27;19,18,39 days.

The correct text is :

आर्क्षस्त्रिकृत्त्रिर्द्युगस्त्रिकृच्च  
क्षणाः क्षणार्धं च कलाश्च तिस्रः ।  
कलांशकानां च त्रिसप्तकाग्रं  
शतं विभक्तं दलितैः स्वमासैः ॥१३॥

*Ārkṣastrikṛtirirdyugāstrikṛcca*  
*kṣaṇāḥ kṣaṇārdham ca kalāśca tisraḥ* |  
*Kalāṁśakānām ca trisaptakāgram*  
*śataṁ vibhaktaṁ dalitaiḥ svamāsaiḥ* || 13 ||

meaning : "A sidereal month consists of  $3^2 \times 3$  days,  $3^2$  *kṣaṇas* (*muhūrtas*) plus half a *kṣaṇa*, 3 *kalās* plus a fraction of a *kalā* equal to 121 divided by half (the number) of its own (*i.e.* sidereal) months (in a *yuga*)."

That is,

one sidereal month = 27 days +  $9\frac{1}{2}$  *muhūrtas* +  $3\frac{121}{1103}$  *kalās*.

because there are 2206 sidereal months (or Moon's revolutions) in a *yuga*,

$$= \frac{60272}{2206} \text{ civil days,}$$

because 20 *kalās* = 1 *muhūrta* and 30 *muhūrtas* = 1 civil day.

This is true because there are 60272 civil days and 2206 sidereal months in a *yuga*.

## 8. INTERCALARY DAYS IN A SOLAR YEAR

Verse 19(a-c) gives the number of intercalary days in a solar year and the number of intercalary months in a given number of solar years. Pingree's text and translation run thus :

Text : एकादशैकाद[श] भागयुक्त्या  
युगादगताब्दान् विहतान् विभज्य ।  
षट्पंचकेनाधिकमासकास्ते  
... .. ॥१९॥

*Ekādaśaikāda [śa] bhāgayuktyā  
yugādगतābdān vihatān vibhajya |  
Ṣaṭpañcakenādhikamāsakāste  
|| 19 ||*

*Translation :* The number of years which have passed of the *yuga* is to be multiplied by 11;11 and divided by 30 : (the result is the number of (lapsed) intercalary months.

*Remarks :*

The text is correct with one exception that there should be "*yutya*" in place of "*yuktyā*" in the first line. But the translation is erroneous because the number 11;11 (denoting  $11\frac{11}{60}$ ) is wrong. There are  $11\frac{1}{11}$  intercalary days in a solar year, not  $11\frac{11}{60}$ . The correct translation is :

"The number of years which have passed of the *yuga*, multiplied by  $11\frac{1}{11}$  and divided by 30 gives the number of intercalary months (in that period)."

This is true because there being 1980 solar months and 2041 synodic months in a *yuga*, there are 61 intercalary months in a *yuga*. Likewise there are  $\frac{61 \times 30}{165}$  or  $11\frac{1}{11}$  intercalary days in a year.

## 9. OMITTED TITHIS IN A YUGA

Verse 5 gives length of a *tithi* in terms of civil days, the length of a civil day in terms of *tithis*, and the number of omitted *tithis* in a *yuga*. Pingree's text and translation run thus :

Text : दिनं चतुः षष्टिलवोनमाहु-  
स्तिथिं प्रषष्ट्यन्त्यमहस्तु सर्वम् ।  
द्विषष्टिभागं नवतिः सहस्रं  
युगे त्वृतनामपञ्चदशतम् ॥५॥

*Dinaṃ catuṣṣaṣṭīlavonamāhu-  
stīthim praśaṣṭyantyamahastu sarvaṃ |  
Dviṣaṣṭībhāgaṃ navatīḥ sahasraṃ  
yuge tvṛtūnāmapasuddhaśatam || 5 ||*

*Translation :* They say that a *tithi* equals a day minus  $\frac{1}{64}$  th, but that every day equals a *tithi* plus  $\frac{1}{60}$  th. In a *yuga* there are 990 seasons (*ṛtu*), (each) consisting of 62 (*tithis*).

*Remarks :*

(1) This translation is incorrect, because

(i) if one *tithi* consists of  $1 - \frac{1}{64}$  civil day, a civil day cannot be equal to  $1 + \frac{1}{60}$  *tithis* ; and

(ii) if there are 990 seasons in a *yuga* and 62 *tithis* in a season, there must be  $990 \times 62$  or 61380 *tithis* in a *yuga*, but according to vs. 6 there are only 61230 *tithis* in a *yuga*.

(2) The text given by Pingree is faulty, because he has adopted the incorrect reading "*dviṣaṣṭībhāgaṃ navatīḥ*" in place of the correct reading "*triṣaṣṭībhāgena yutam*" and the incorrect reading "*tvṛtūnāmapasuddhaśatam*" in place of the correct reading "*vamānāmapasaptaśatkam*". Partially correct readings occur in the apparatus.

(3) The correct reading of the text is :

दिनं चतुः षष्टिलवोनमाहु-  
स्तिथिं प्रषष्ट्यन्त्यमहस्तु सर्वम् ।  
त्रिषष्टिभागेन युतं सहस्रं  
युगेऽवमानामपसप्तशतकम् ॥५॥

*Dinaṃ catuṣṣaṣṭīlavonamāhu-  
stīthim praśaṣṭyantyamahastu sarvaṃ |  
Triṣaṣṭībhāgena yutaṃ sahasraṃ  
yuge 'vamānāmapasaptaśatkam || 5 ||*

meaning : "They say that a *tithi* is equal to a day minus  $\frac{1}{64}$  of a day, correct upto the sixtieth of a sixtieth (of a day, i.e. up to *vighaṭṣ*), and a day equals a whole *tithi* plus  $\frac{1}{63}$  of a *tithi*. The number of omitted *tithis* in a *yuga* is equal to 1000 minus 42 (i.e. 958)."

This can be easily proved to be true. For, in a *yuga*

(i) no. of *tithis* = 61230, and  
no. of civil days = 60272.

Therefore, one *tithi* =  $\frac{60272}{61230} = 1 - \frac{1}{64}$  civil day,  
 and one civil day =  $\frac{61230}{60272} = 1 + \frac{1}{63}$  *tithis*.

Both the results are correct upto *vighatīs*.

(ii) no. of omitted *tithis* = *tithis* – civil days = 61230 – 60272 = 958.

#### 10. CONCLUSION

From the above discussion, we conclude that the *yuga* defined in the *Yavanajātaka* contains :

Solar years = 165

Solar months = 165 × 12 = 1980

Solar days = 165 × 360 = 59400

Civil days = 60272

Synodic months = 2041

Intercalary months = synodic months – solar months  
 = 2041 – 1980 = 61 (vide vs. 10)

Synodic days or *tithis* = 2041 × 30 = 61230

Omitted *tithis* = *tithis* – civil days  
 = 61230 – 60272 = 958

Sidereal months (or Moon's revolutions)  
 = synodic months – Sun's revolutions  
 = 2041 – 165 = 2206

Risings of asterisms (or Earth's rotations)  
 = civil days + Sun's revolutions  
 = 60272 + 165 = 60437

Risings of the Sun = Risings of asterisms – Sun's revolutions (vide vs. 8)  
 = 60437 – 165 = 60272

Risings of the Moon = Risings of asterisms – Moon's revolutions  
 = 60437 – 2206 = 58231 (vide vs. 8)

Solar year = 6,5;17,5,27,16 days

Sun's mean daily motion = 0;59,7,55,28 degrees

Synodic month = 29;31,50,14,24 days

Sidereal month = 27;19,18,39 days

According to *Sūrya-siddhānta* :

Solar year = 6,5;15,31,3 days

Sun's mean daily motion = 0;59,8,10,10 degrees

Synodic month = 29;31,50 days

Sidereal month = 27;19,18 days.